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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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# EFFECTS OF MECHANIZATION ON PRODUCTIVITY: SOUTH SULAWESI, INDONESIA

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# THE EFFECT OF MECHANIZATION ON PRODUCTIVITY IN SOUTH SULAWESI*/

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## ABSTRACT

The mechanization of land preparation has been expected to increase rice yield/ha. A study was undertaken in South Sulawesi in 1979-81 to evaluate the impact of mechanization on yields. Results of this research showed that after adjusting for crop failure and differences in fertilizer application there was no evidence to support the expection that mechanization increases yield.

## I. INTRODUCTION

Agricultural extension agents and various Government officials have contended that due to a lack of power, rice land preparation is done by men and animals. It is contended that because power tillers and tractors can plow the land deeper and more completely, yield/ha can be increased if mechanized land preparation is adopted. Based on these assumptions, mechanization of land preparation has been promoted to encourage farmers to purchase mini tractors/power tillers in both densely populated Java - Bali and in the sparsely inhabited outer islands of Sulawesi and Sumatra.

## II. OBJECTIVES

The purpose of this paper is to evalute the impact of mechanization on rice yields. This issue will be evaluated by :

(1) comparing yields achieved on non-mechanized and mechanized farms.
(2) comparing yields achieved on non-mechanized and mechanized farms, adjusted for differences in crop failure.
(3) comparing yields achieved on mechanized and non-mechanized farms, adjusted for crop failure and differences in fertilizer use.

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## III. STUDY AREA

Sidrap and Pinrang Districts are located about 200 km north of Ujung Pandang, the capital of South Sulawesi. This area was chosen as the research site because 51% of all the mini-tractors in the Province are found in these districts (Haamun, 1979).

These districts have a population density of about 100 persons/km$^2$ close to one-third of the agricultural area is irrigated, lowland rice yields average around 3.0 t/ha, and they have a mini-tractor population of nearly 600 units. (Sarasutha, 1981).

## IV. SURVEY DESIGN

Sampling. Sampling procedures were developed to identify a stratified sample of respondents who represented the existing agricultural diversity. First, a random sample of eight sub-districts (among the two districts) with ten or more tractors was identified. Then, four villages in each district with five or more tractors were randomly selected. Next, a block census of the eight villages was conducted covering over 2000 households. Based on data collected, strata were chosen to represent the typical environments and power sources as shown in Table 1.

Survey. Data was collected with a comprehensive questionnaire developed and used to interview about 250 respondents during the 1979 wet, 1979/80 dry (second crop), 1979/80 dry (third crop), 1980 wet and 1980/81 dry (second crop) seasons. In addition, weekly work record were maintained during the first four seasons (1979 wet through 1980 wet) including all environment/power source strata covered by the survey, but concentrated in 4 out of 8 villages and 70 farmers. Analysis presented in this paper is based on the data collected on the 1979 wet, 1980 wet, and 1980/81 dry seasons using the survey data.

## V. RESULT

Data on yields, fertilizer use and crop failure is presented in Table 1, for non-mechanized and mechanized farms.

Yield differences. Initial review of the data in Table 2 (col.1) suggests that mechanized farms have higher yields than non-mechanized. Over the three seasons considered, yields on mechanized farms were 448 kg/ha (W.S 1979) and 197 kg/ha (1980 W.S.) greater in two seasons, but 57 kg/ha less in one season (D.S. 1980/81) than non-mechanized farms.

Yield differences, adjusted for crop failure. As shown in Table 1, crop failure due to drought was particularly severe in the 1979 W.S. While the incidence of failure was greater in rainfed than irrigated areas, non-mechanized farms (20%) were more severely affected than mechanized (11%). Consequently, yields have been adjusted to compensate for this exogenous impact. After compensating for differences in crop failure (Table 2, col.2), the yield differences between mechanized and non-mechanized farms falls from 448 to 402 kg/ha (W.S. 1979), increases from 197 to 227 kg/ha (W.S. 1980); and increases from 57 to 155 kg/ha higher yield in non-mechanized than mechanized (D.S. 1979/80).

Yield differences, adjusted for crop failure and fertilizer use. Data in Table 2 (col.3) shows the difference in level of fertilizer applied by mechanized, compared to non-mechanized farms. In all seasons, the rate of application is greater on mechanized farms, ranging from 81 kg/ha (D.S. 1980/81) to 97 kg/ha (W.S. 1979) more, depending on the season considered.

By assuming various values for the average increase in yield resulting from one additional kg. of fertilizer, the contribution of higher fertilizer use on mechanized farms can be netted out. In Table 2, using yields adjusted for crop failure, it is assumed the average productivity of one kg. of fertilizer is 10 kg (col.6), 9 kg (col.9) and 8 kg (col.12) of yield increase/kg. of fertilizer applied. For all seasons, these adjustments result in a negative yield difference i.e. non-mechanized yields are higher than mechanized yields.

Alternatively, this analysis can be presented in terms of breakeven analysis. In Table 2, the value in parentheses after column 1 is the average fertilizer productivity that must be assumed to equalize non-mechanized and mechanized yields - before adjusting for crop loss. The value in parentheses after column 2 is the average fertilizer productivity that must be assumed to equalize mechanized and non-mechanized yields - after adjusting for crop losses. From this data, a modest average fertilizer productivity assumption of 6.3 kg yield increase per kg of fertilizer is required to net out the yield differences in the rainfed environment W.S. 1979, and rainfed 1980/81 D.S.; 36 kg on irrigated farms in the 1980 D.S.; and 2.8 kg on irrigated farms in the 1979 W.S. No assumption about fertilizer productivity is required in the rainfed area for the 1980 W.S. and irrigated farms for the 1980/81 D.S. Because non-mechanized yields are already higher than mechanized yields.

## VI. CONCLUSION

After comparing yields on mechanized and non-mechanized farms, it is often concluded that mechanization increases yields because yields are higher on mechanized farms. Yet, because farmers who choose to mechanize also typically use higher input levels, such conclusions may be unjustified. After adjusting yield differences to take into consideration differences in crop losses and input use, it was found that in all three seasons, higher yields were observed on non-mechanized farms.


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## REFERENCES


Sarasutha, I.G.P., 1981. Effect of Mechanization on Intensity of Land Use, South Sulawesi, Indonesia., paper presented at the Consequences of Small Rice Farm Mechanization Workshop at IRRI, Los Banos, Philippine, September 14-18, 1981.

Table 1. Yield and Fertilizer Use per Ha Consequences Cooperators, South Sulawesi, 1979-1980.

| | Non-Mechanized | | | Mechanized | | |
|---|---|---|---|---|---|---|
| | Rain-fed | Irri-gated | Aggre-gate | Rain-fed | Irri-gated | Aggre-gate |
| **Wet Season 1979** | | | | | | |
| - No. of Reporting | 84 | 82 | 166 | 48 | 76 | 124 |
| - Fertilizer : | | | | | | |
| - Urea (Kg) | 45 | 45 | 45 | 84 | 136 | 116 |
| - TSP (Kg) | 1 | 5 | 3 | 3 | 52 | 33 |
| - ZA (Kg) | 2 | 16 | 9 | 3 | 6 | 5 |
| - Total (Kg) | 48 | 56 | 57 | 90 | 194 | 154 |
| - Yield (Kg) | 508 | 1,099 | 800 | 768 | 1,551 | 1,248 |
| - Crop Failure (%) | 26 | 13 | 20 | 19 | 6 | 11 |
| - Yield if CF = 0% a/ | 686 | 1,263 | 1,000 | 948 | 1,650 | 1,402 |
| **Wet Season 1980** | | | | | | |
| - No. of Reporting | 71 | 30 | 101 | 40 | 83 | 123 |
| - Fertilizer : | | | | | | |
| - Urea (Kg) | 89 | 107 | 94 | 108 | 156 | 140 |
| - TSP (Kg) | 74 | 75 | 75 | 69 | 98 | 89 |
| - ZA (Kg) | 31 | 46 | 35 | 58 | 70 | 66 |
| - Total (Kg) | 194 | 229 | 204 | 235 | 324 | 295 |
| - Yield (Kg) | 2,552 | 2,548 | 2,551 | 2,413 | 2,910 | 2,748 |
| - Crop Failure (%) | | 3 | 1 | - | 2 | 2 |
| - Yield if CF = 0% a/ | 2,552 | 2,627 | 2,577 | 2,413 | 2,969 | 2,804 |
| **Dry Season 1980/81** | | | | | | |
| - No. of Reporting | 78 | 53 | 131 | 7 | 104 | 111 |
| - Fertilizer : | | | | | | |
| - Urea (Kg) | 103 | 77 | 93 | 130 | 152 | 151 |
| - TSP (Kg) | 33 | 61 | 44 | 74 | 59 | 60 |
| - ZA (Kg) | 0 | 36 | 15 | 25 | 22 | 22 |
| - Total (Kg) | 136 | 174 | 152 | 229 | 233 | 233 |
| - Yield (Kg) | 4,214 | 5,655 | 4,799 | 4,841 | 4,735 | 4,742 |
| - Crop Failure (%) | 1 | 2 | 2 | 0 | 0 | 0 |
| - Yield if CF = 0% a/ | 4,257 | 5,770 | 4,897 | 4,841 | 4,735 | 4,742 |

a/ Yield after adjusting for area affected by crop failure (harvested area yield).

Sources : Consequences of land preparation Mechanization in Indonesia : South Sulawesi and West Java.

Table 2. Yields on Non-Mechanized and Mechanized Farms, Adjusted For Crop Failure and Differences in Fertilizer Application, Sidrap and Pinrang Districts, South Sulawesi, 1979 - 1981.

| Season | Yield diff. (unadjusted) a/ (Kg/Ha) | Yield diff. (adjusted) b/ (Kg/Ha) | Diff. in c/ fert. app. (Kg/Ha) | 1 kg fertilizer = 10 kg rice: Expected yield d/ diff. due to diff. level of fert. app. (Kg/Ha) | (1-4) (Kg/Ha) | (2-4) (Kg/Ha) | 1 kg fertilizer = 9 kg rice: Expected yield d/ diff. due to diff. level of fert. app. (Kg/Ha) | (1-7) (Kg/Ha) | (2-7) (Kg/Ha) | 1 kg fertilizer = 8 kg rice: Expected yield d/ diff. due to diff. level of fert. app. (Kg/Ha) | (1-10) (Kg/Ha) | (2-10) (Kg/Ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **Wet Season 1979** | | | | | | | | | | | | |
| 1. Rainfed mech. vs rainfed non-mech. | +260(6,2) | +262(6,2) | + 42 | + 420 | - 160 | - 158 | + 378 | - 118 | - 116 | + 336 | - 76 | - 74 |
| 2. Irr mech vs irr.non-mech. | +452(3,3) | +387(2,8) | +138 | +1380 | - 928 | - 993 | +1242 | - 790 | - 853 | +1104 | - 652 | - 717 |
| 3. Agg.mech.vs Agg.non-mech. | +443(4,6) | +402(4,1) | + 97 | + 970 | - 522 | - 568 | + 875 | - 425 | - 471 | + 776 | - 328 | - 374 |
| **Wet Season 1980** | | | | | | | | | | | | |
| 1. Rainfed mech. vs rainfed non mech. | -139(NA) | -139(NA) | + 41 | + 410 | - 549 | - 549 | + 369 | - 508 | - 508 | + 328 | - 467 | - 467 |
| 2. Irr.mech. vs irr.non-mech. | +362(3,8) | +342(3,6) | + 95 | + 950 | - 588 | - 608 | + 855 | - 493 | - 513 | + 760 | - 398 | - 418 |
| 3. Agg.mech.vs Agg.non-mech. | +197(2,2) | +227(2,5) | + 91 | + 910 | - 713 | - 683 | + 819 | - 622 | - 592 | + 728 | - 531 | - 501 |
| **Dry Season 1980/1981** | | | | | | | | | | | | |
| 1. Rainfed mech. vs rainfed non-mech. | +627(6,7) | +584(6,3) | + 93 | + 930 | - 303 | - 346 | + 837 | - 210 | - 253 | + 744 | - 177 | - 160 |
| 2. Irr.mech.vs irr.non-mech. | -920(NA) | -1035(NA) | + 59 | + 590 | -1510 | -1625 | + 531 | -1451 | -1566 | + 472 | -1392 | -1507 |
| 3. Agg.mech.vs Agg.non-mech. | - 57(NA) | -155(NA) | + 81 | + 810 | - 867 | - 965 | + 729 | - 786 | - 884 | + 648 | - 705 | - 803 |

a/ Mechanized yields minus non-mechanized yields.
b/ Mechanized yields minus non-mechanized yields, after adjusting for crop failure.
c/ Mechanized fertilizer application rate minus non-mechanized fertilizer application rate.
d/ Expected yield difference between mechanized and non-mechanized after adjusting for various levels of yield response to fertilizer application.
NA = Not Applicable.

Sources : Consequences of land preparation Mechanization in Indonesia : South Sulawesi and West Java.

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CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Working Papers

1. Juarez, F. and B. Duff. The Economic and Institutional Impact of Mechanical Threshing in Iloilo and Laguna. October 1979.

2. Pathnopas, R. The Economics of Rice Threshing Machines in Thailand: A Case Study of Chachoengsao and Supanburi Provinces. October 1979.

3. Gardezi, J., A. Rauf, M. Munir, K. Altaf, Q. Mohd-ud-Din, and B. Lockwood. A Study of Mechanical and Traditional Wheat Threshing in Multan District, Punjab, Pakistan: Some Preliminary Results. October 1979.

4. Habito, C. and B. Duff. A Simulation Model to Evaluate Mechanization of Rice Postharvest Operations in the Philippines. October 1979.

5. Chapman, J. The Potential of Mechanization for Crop Intensification in a Rainfed Area - Iloilo, Philippines. October 1979.

6. Thapa, G. The Economics of Tractor Owernship and Use in the Nepal, Terai. October 1979.

7. Jongsuwat, N. Productivity Growth and Farm Machinery Adoption in Thai Agriculture. April 1980.

8. Bernsten, R.H. and R. Sinaga. A Methodology for Identifying Lowland Rice Farms that Would Benefit from the Mechanization of Land Preparation. October 1979.

9. Bernsten, R. H. and A. Rochim. Labor Shortage as a Constraint to Increasing Cropping Intensity. Revised March 1980.

10. Ayob, A.M. The Economics and Adoption of the Combine Harvester in the Muda Region of Malaysia. October 1979.

11. Lubis, R. Impact of Cropping Pattern Technology on Income, Employment and Production: A Case Study on Expanded Crop Production in Lampung. October 1979.

12. Wicks, J. A. Modelling the Consequences of Future Mechanization: An Outline of Possible Procedures. October 1979.

13. Khoju, M.R. and J. A. Wicks. Economics of Pump-Irrigation in Eastern Nepal. August 1980.

14. Tan, Y. L., J.P.G. Webster and J. A. Wicks. The Decomposition of Differences in Output Between Two Groups of Farms. Revised 1981.

15. Herdt, R. W. Mechanization of Rice Production in Developing Asian Countries: Perspective, Evidence, and Issues. September 1981.

16. Lantin, R. M. Mechanization Policy and the National Agricultural Mechanization Council - Philippines. September 1981.

17. Lockwood, B. Farm Mechanization in Pakistan: Policy and Practice September 1981.

18. Wiboonchutikula, P. The Total Factor Productivity Growth of the Three Digit Manufacturing Industries in Thailand. September 1981.

19. Ahammed, C. S. and R. W. Herdt. A General Equilibrium Analysis of the Effects of Rice Farm Mechanization in the Philippines. September 1981.

20. Mikkelsen, K. and N. Langam. Technology Change in the Philippine Agricultural Machinery Industry. September 1981.

21. Boughton, D. Energy Use in Alternative Rice Production Systems in Nueva Ecija, Central Luzon, Philippines. September 1981.

22. Hurun, A. Financial Analysis of Power Tiller Ownership in Mariuk Village, West Java, Indonesia. September 1981.

23. Hafsah, J. The Economics of Tractor Operation and Use in South Sulawesi, Indonesia. September 1981.

24. Maranan, C. L. A Comparative Analysis of Tractor Contract Operations in Nueva Ecija, Philippines, 1972 and 1980. September 1981.

25. Monge, V. S. and B. Duff. Analysis of the Demand for Farm Power for Small Rice Farm Agriculture in Nueva Ecija, Philippines. September 1981.

26. Munir, M. An Evaluation of the Farmers' Decision-Making for Investment in Farm Machinery. September 1981.

27. Jabbar, M. A., Md.S. R. Bhuiyan and A. K. Maksudul Bari. Causes and Consequences of Power Tiller Utilization in Two Areas of Bangladesh. September 1981.

28. Juarez, F. and R. Pathnopas. A Comparative Analysis of Thresher Adoption and Use in Thailand and the Philippines. September 1981.

29. Ahmed, J. U. Labour Use Pattern & Mechanization of Paddy Postharvest Processing in Bangladesh. September 1981.

30. Colter, J. M. The Impact of Handtractors on Income and Employment Opportunities of Migrant Laborers in Java. September 1981.

31. Santoso, K. The Potential for Agricultural Mechanization and Labor Markets in East Java. September 1981.

32. Bernsten, R. H. Effects of Mini-Tractor Mechanization on Employment and Labour Use Intensity, Sidrap and Pinrang, South Sulawesi, Indonesia. September 1981.

33. Collier, W. Improved Cropping Patterns, Labor Absorption and Small Farm Mechanization in Indonesia. September 1981.

34. Moran, P. B. and E. Camacho. Consequences of Farm Mechanization Project Site Description: Philippines. September 1981.

35. Generalla, A. C. and A. Aguilar. Effects of Mechanization on Intensity of Land Use. September 1981.

36. Tan, Y. and J. A. Wicks. Production Effects of Mechanization. September 1981.

37. Sison, J. F. and P. B. Moran. Farm Labor Utilization and Employment in Two Selected Municipalities in Nueva Ecija - A Preliminary Analysis. September 1981.

38. Saefuddin, Y. Site Description: Mechanization Consequences Project in West Java, Indonesia. September 1981.

39. Handaka, S. Effects of Mechanization on Intensity of Land Use, West Java, Indonesia. September 1981.

40. Handaka, S. A Technical and Economic Evaluation of Rice Mills in West Java, Indonesia. September 1981.

41. Sinaga, R. Effects of Mechanization on Productivity: West Java, Indonesia. September 1981.

42. Sinaga, R. Effects of Mechanization on Productivity: South Sulawesi, Indonesia. September 1981.

43. Sri-Bagyo, A. The Impact of Mechanization on Production and Employment in Rice Areas of West Java, Indonesia. September 1981.

44. Maamun, Y. Site Description: Mechanization Consequences Project in South Sulawesi. September 1981.

45. Sarasutha, I. G. P. and R. Bernsten. Effect of Mechanization on Intensity of Land Use, South Sulawesi, Indonesia. September 1981.

46. Bockhop, C. W. and M. Nafziger. The Impact of Economics upon the Design of Machinery at IRRI. September 1981.